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Multi-channel Unbounded Optical Communication through Modulation of LED Lighting

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ELECTRICAL AND COMPUTER

Multi-channel Unbounded Optical Communication through modulation of LED lighting

CAPSTONE DESIGN EXPO 2016

Motivation

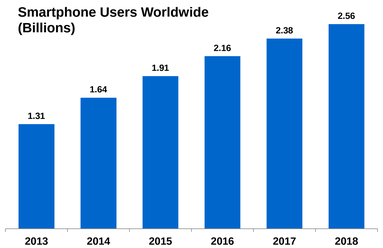
Increasing demand for bandwidth and speed

- 71% of the workforce would use more demanding apps if bandwidth were available [1]

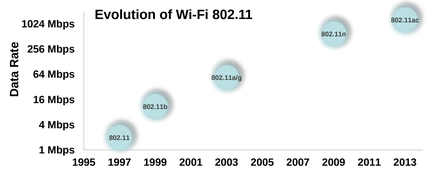
Li-Fi: LEDs for efficient lighting and communications

- Modulation up to 500MHz while providing general lighting
- Tbps vs. Gbps for Wi-Fi
- No electromagnetic interference
- Line of sight secure communications

[1] Ubiquiti Networks. "State of Wi-Fi Report", *CTIA* 2013.



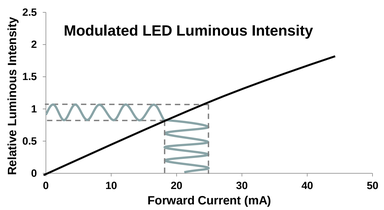
Source: eMarketer, Dec. 2014

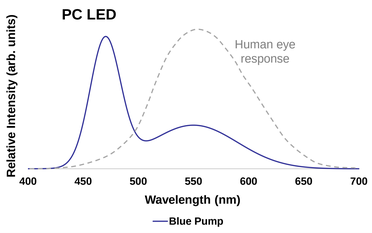


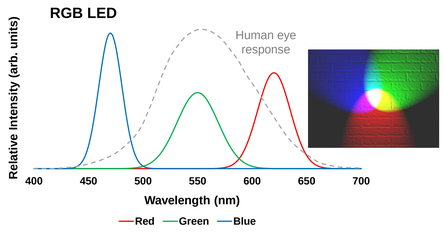
LED Background

The two primary methods for achieving white light using LEDs:

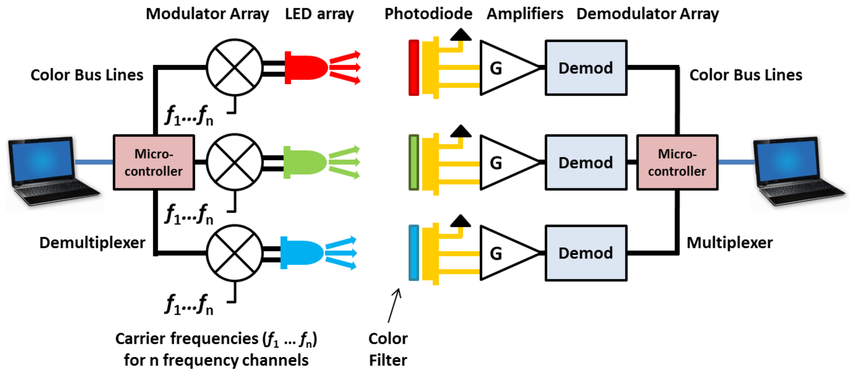
- **Phosphor converted (PC)** LED uses a **blue LED pump** to excite yellow & red phosphors, offering a lower cost
- **RGB** LED bulb mixes red, green, and blue LEDs, offering better color rendering







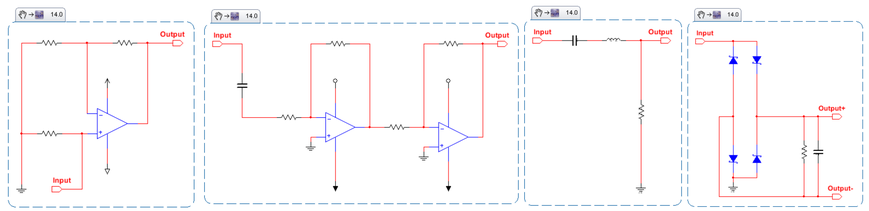
System Schematic



Transmitter (3 colors, n carrier frequencies = 3n channels)

- **Wavelength division multiplexing:** Using **RGB LEDs** and **color filters**
- **Frequency division multiplexing:** Using **crystal oscillators** and **bandpass filters**

Receiver



Transimpedance Amplifier – Converts the incoming photocurrent to a voltage signal

Voltage Amplifiers – Provide a gain of over 100 and act as a buffer between stages

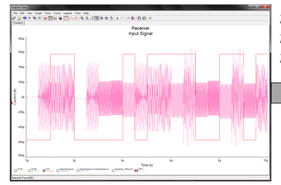
Bandpass Filter – Filters out only the frequency for each channel.

Rectifier/Integrator – Converts the signal back to a digital signal

Acknowledgments

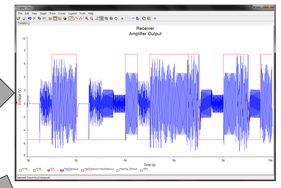
We thank Dr. Cabral and Dr. Filippas for their advice on integrated circuits, and Dr. Docef for his guidance with communication systems. We also thank the School of Engineering and the Sternheimer fund for supporting this project.

Simulations by Multisim



f_1=30 MHz
f_2=50 MHz
f_3=64 MHz

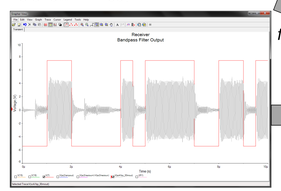
Input signal from three frequencies and one color. f_1=30 MHz bitstream is shown in red.



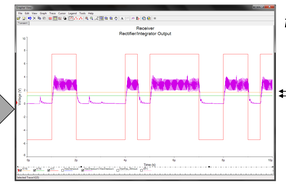
f_1=30 MHz
f_2=50 MHz
f_3=64 MHz

Amplifier output showing gain of approximately 100.

f_1=30 MHz



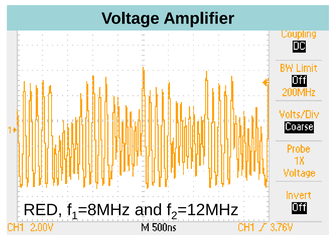
Bandpass filter output showing only f_1=30 MHz passed through.

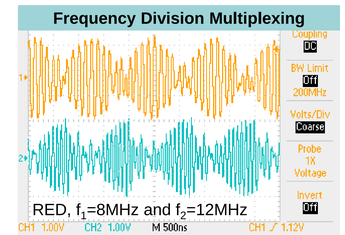


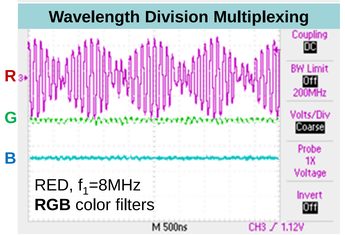
f_1=30 MHz

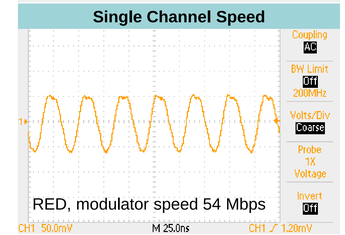
Rectifier/Integrator output showing original f_1=30 MHz bitstream.

Experimental Results









Future Improvements

- Develop a better method for networking (data processing, multiplexing, etc.)
- Add a yellow LED, and use more frequencies

Total transfer rate: 3 colors x 3 freq. x 54Mbps = 486Mbps

VCU School of Engineering

Make it real.

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